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Amenities and Rural Appalachia Economic Growth

Steven Deller and Victor Lledo

Patterns of economic growth in rural Appalachia are examined with a focus on natural and built amenities. While the literature is clear that rural areas endowed with scenic beauty, lakes, forests, and wildlife, among other natural amenities, and coupled with built amenities such as golf courses, are experiencing robust economic growth. It is not clear if these patterns extend to rural Appalachia. In this applied research study we use data for rural U.S. counties. We estimate an augmented Carlino-Mills growth model with specific attention to growth patterns of Appalachia. We also build on the empirical modeling by adopting a Bayesian Modeling Average (BMA) approach to address the problem of model specification. We find that while there are some commonalities across the whole of the United States, the country is sufficiently heterogeneous that impact of amenities or other policy variables may be significantly different depending on where one is within the country. Our results suggest that while non-metropolitan Appalachia tends to follow national trends, there are sufficient differences that warrant special attention.

Key Words: amenities, quality of life, rural economic growth, Bayesian

The importance of amenities and overall quality of life in explaining rural growth patterns is becoming widely accepted within the rural growth literature (Power 1988, 1996, Power and Barrett 2001, OECD 1994, 1996, 1999, McGranahan 1999, Isserman 2000, Deller and Tsai 1999, Dissart and Deller 2000, Green 2001, Marcouiller, Deller, and Green 2005, Green, Deller, and Marcouiller 2005). Both descriptive analysis (e.g., McGranahan 1999) and more advanced statistical modeling approaches (e.g., Deller et al. 2001, Marcouiller, Kim, and Deller 2004, Deller et al. 2005) have consistently found that rural areas that are endowed with natural and built amenities such as scenic beauty, wildlife, and recreational and tourism attributes experience higher rates of structural change and economic growth than the U.S. average. Unfortunately, much of the current thinking is based on empirical evidence with little if any theoretical foundations (Power 1996, 2005).

Using traditional neoclassical growth theory, Marcouiller (1998) and Marcouiller and Clendenning (2005) suggest that natural amenities and quality of life factors act as non-market latent inputs into regional economic growth and development. As our national economy has moved from goods- to service-producing, the impact on rural America has been pronounced. No longer do traditional extractive industries (i.e., agriculture, forestry, mining, etc.) or manufacturing form the backbone of the rural economy. Today, capital is no longer viewed as simply the machinery or public infrastructure used in production, but rather the more relevant form of capital takes a latent non-market attribute. The importance of a forest to a regional economy, for example, is no longer just timber production but rather the natural amenities and recreational attributes of the forest (White and Hanink 2004).

The notion that amenities and quality of life in general play an important role in regional economic growth is not necessarily a new idea within the regional growth literature. Graves (1979, 1980, 1983) was the first to make popular the argument that rising income and wealth leads to an increased demand for location-specific amenities.

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Graves argued that the historically poor performance of migration prediction studies was directly attributable to their failure to account for amenity factors. Theoretical work by Roback (1982, 1988) and Blanchflower and Oswald (1996) suggests that amenities and quality of life factors are capitalized into wages, rents, and unemployment in a manner that could hinder broader economic growth policies. In short, people are willing to accept lower levels of income, pay higher rents, and risk higher levels of unemployment to live in a high amenity and quality of life region. In a more focused study on firm location, Granger and Blomquist (1999) find comparable results for manufacturing. As noted by Power (2005), if such capitalization exists, then comparing traditional metrics of economic growth and development, such as income and unemployment, may provide distorted pictures of actual economic well-being.

The literature examining rural economic growth is plagued with several problems that need to be addressed before sound policy recommendations can be advanced. First, how do we define economic growth? If we define growth narrowly in terms of population growth or migration flows, then the literature is clear: high amenity areas experience more growth. If, however, we define growth as including employment, income levels, and unemployment, the literature is not as clear (Deller and Tsai 1999, Deller et al. 2001, Deller et al. 2005). Goe and Green (2005) argue that the literature needs to worry more about how we define growth and pay greater attention to the notion of economic development.[1]

Second, amenities and quality of life are easy to conceptualize but are particularly elusive to empirically measure. A common practice within the literature is to confine amenities to a single dimensional attribute, such as climate or crime rates, or to introduce an ad hoc list of selected attributes (Andrews 1980). For example, the widely referenced work on rural growth by USDA's Economic Research Service defines natural amenities as a summary index of mild sunny winters, moderate summers with low humidity, varied topography, mountains, and the abundance of water (Nord and Cromartie 1997, McGranahan 1999). In his review of empirical firm location literature, Gottlieb (1994) concluded that the literature attempting to link amenities with economic growth has tended to be ad hoc and not sufficiently matured, theoretically or empirically. While progress has been made in the measurement of amenities and quality of life, much work needs to be done. Indeed, the methods that we employ to measure amenities are but one small step toward a more comprehensive empirical approach.

Third, the unit of analysis for empirical work is not clear. Some built amenity attributes, such as a museum and/or historical sites, are specific to one spatial location, while other natural amenities, such as a forest or ecosystem, cover large regions. Further complicating the issue is the range of influence of the attribute under consideration. For example, the Chicago Art Institute has a much larger geographic draw than does the Elvehlem Museum in Madison, Wisconsin. Unfortunately, the data used in the literature is reported at the municipal and/or county level. The introduction of NORSIS (National Outdoor Recreation Statistical Information System), compiled by the U.S. Forest Service, which contains a wide range of data on outdoor recreational facilities, natural resources, and cultural/historical attractions, among other variables, has opened a wide range of research possibility. The NORSIS data, along with the BEA-REIS (Bureau of Economic Analysis, Regional Economic Information System) employment and income data, is reported at the county level. Possible approaches to address this problem are to capture spatial relationships in the error structure using spatial econometric techniques, the aggregation of counties into functioning economic areas such as commuting zones on the premise that the functioning economic area reflects the sphere of influence of the basket of local amenities, or perhaps the construction of spatially weighted county observations that reflect the concentration of an amenity within the region.[2]

Fourth, the rural growth literature is subject to

[1] Some, such as Partridge and Rickman (2003), suggest that most of our traditional measures of economic growth are only indirect measures of economic development and well-being. Growth is easily defined as "more" in the sense of more jobs, more income, and more people, whereas development is more of a normative concept and difficult to measure. The distinction between growth and development is vital to moving economic policy forward (Shaffer, Deller, and Marcouiller 2004), but a detailed discussion is beyond the scope of this particular study, which focuses on growth.

[2] These suggestions are not followed up upon in this particular study but will be the subject of future research efforts.

the same critique that the larger macroeconomic growth literature has been subject to: how do researchers determine the specification of the commonly referred to "conditional variables"? As argued by Levine and Renelt (1992), Pack (1994), Barro (2007), Sala-i-Martin (1997), Schultz (1999), Durlauf and Quah (1999), Fernadez, Ley, and Steel (2001), and Brock and Durlauf (2001), the growth literature is awash with studies that document the correlation of a host of variables with growth, but there is little if any theoretical foundation for the selection of a specific set of regressors. Theory tells us, for example, that human capital matters—but how should it be measured and how many dimensions should be included? As noted by Marcouiller (1998) and Marcouiller and Clendenning (2005), the lack of any theoretical insights, or in the case of conflicting theoretical predictions, the natural and built amenity determinants of growth, reduces to an empirical question.

The intent of this applied research study is to more formally introduce the problem of model specification into the rural growth literature, with specific attention paid to the role of amenities within the Appalachian region of the United States. Rural Appalachia is a particularly interesting region for focused analysis for several reasons. Rural Appalachia's traditional dependence on mining, agriculture, and forestry has caused it to lag behind the rest of rural America. Yet rural Appalachia is endowed with tremendous scenic beauty, wildlife, and recreational opportunities. If a new engine of economic growth is the non-consumptive use of natural resources, has rural Appalachia been able to take advantage of its resources? Can the growth patterns affecting, for example, the mountainous west, be applied to rural Appalachia? Is access to natural amenities sufficient to ensure growth, or are human-built amenities required to take advantage of those natural amenities and quality of life attributes? Work by Green, Deller, and Marcouiller (2005) suggest that simply having access to natural amenities is not sufficient to ensure growth. They conclude that some basic economic infrastructure (or built amenities), such as recreational businesses, need to be in place to capture economic activity. Does this same general conclusion apply to rural Appalachia?

We broaden our notion of economic growth by using an expanded version of the now classic Carlino and Mills (1987) growth model by looking at growth in population, employment, and per capita income. We also expand our notion of amenities by employing a multidimensional view of amenities based on some of our previous work (Deller et al. 2001, Deller et al. 2005). We do not address the unit of analysis issue in this applied research—we use data at the county level. But we do address the problem of model specification by introducing a variable reduction method referred to as Bayesian Modeling Averaging (BMA) as applied to growth models by Brock and Durlauf (2001) and Fernadez, Ley, and Steel (2001).

In our search for growth patterns in rural Appalachia, this study moves forward in four steps. First we use the BMA method to identify a base model using all U.S. non-metro counties. Included in this step is the inclusion of a simple Appalachia identifier to see if the BMA method identifies rural Appalachia as being different. Second, once a base model is developed, a set of five amenity measures are introduced into the specification of the growth models. The third step introduces a set of Appalachia slope shifters that will allow each variable parameter to vary for Appalachian counties. The final step involves estimating the base and amenity-augmented models using just the data for rural Appalachia.

Using this multi-step process, we make several contributions to our understanding of rural economic growth. First, the BMA approach provides a method of identifying a core model of economic growth. Second, we expand our thinking about how amenities affect economic growth by introducing more complete measures of amenities. Third, we center on regional variations across the country by focusing our attention on Appalachia within the setting of the whole of the United States. Beyond these introductory comments, the study is composed of four main sections. First we review some of the theoretical foundation for the work. We then detail the BMA approach, and follow with a detailed discussion of our amenity measures and the selection of variables to be introduced into the BMA modeling. Our empirical models are then presented and results discussed. We close the study with a review of our findings and offer some possible policy options.

Theoretical Foundations

Models of regional economic growth often focus on the interdependencies of household residential and firm location choices. Often this view addresses the notion of whether "people follow jobs" or "jobs follow people" (Steinnes and Fisher 1974). To address this issue of causation and interdependency, Carlino and Mills (1987) constructed a now classic two-equation system. This model has subsequently been used by a number of regional scientists to examine regional economic growth (Hunt 2006, Boarnet 1994, Boarnet, Chalermpong, and Geho 2005, Duffy 1994, Duffy-Deno 1998, Henry, Barkley, and Bao 1997, Barkley, Henry, and Bao 1998, Henry et al. 1999).

In this applied research, we build on the work of Treyz et al. (1993) by adopting the framework used by Nzaku and Bukenya (2005) and Deller et al. (2001) and expanding upon the original formulation of the Carlino-Mills model to capture explicitly the role of income. We expand the "people vs. jobs" debate from two-dimensional to three-dimensional: "people vs. jobs vs. income." As we detail below, the dynamic framework as outlined by Carlino and Mills is a flexible framework that describes how key economic variables can be structurally interrelated. Part of the popularity of the Carlino-Mills framework is its implicit flexibility.

We suggest that such an expansion of the theoretical model more fully reflects the decision making facing people and firms. As Treyz et al. (1993) argue, when making migration decisions people look at the potential income that might be earned in the region. Traditional neoclassical migration theory maintains that people move from lower to higher income areas. Historically, firms would make the opposite calculations, looking for lower wage areas. But today, as we move from a goods- to a service-producing economy, firms are increasingly looking to the purchasing power within a particular local market. If firms follow people because of the potential market, including income, we provide a more theoretically correct picture of the regional growth process.[3] Independently, the work of Granger and Blomquist (1999) finds comparable results for manufacturing. In addition, we explicitly address the concerns raised by Goe and Green (2005) that our notions of rural growth be expanded to capture a single rudimentary dimension of development. By expanding the model we also address the increasing concerns about job quality related to amenity-based development (Leatherman and Marcouiller 1996, Marcouiller, Kim, and Deller 2004).

Precisely, we construct four central hypotheses in this research:

- Growth is conditional upon historical growth patterns.
- Growth is conditional upon initial conditions.
- Growth is conditional upon regional amenity factors.
- Growth patterns differ across sub-regions of the United States.

The first two hypotheses are drawn directly from the Carlino-Mills framework and are consistent with other studies that have adopted this general theoretical approach. The latter two hypotheses form the heart of the current research agenda. Specifically, factors defining amenities are playing an increasingly important role in regional economic performance. Our goal is to examine formally and rigorously the level and degree of this hypothesized relationship as it relates to amenities. Second, we hypothesize that growth patterns across the United States are uniquely different and can be separated and quantified. Specifically, we postulate that high amenity areas like rural Appalachia that have traditionally lagged behind the United States in general may be in a unique position to experience higher rates of growth.

Relying on Nzaku and Bukenya (2005) and Deller et al. (2001), the general form of the model is

[3] There are three broad theoretical approaches to justify expanding the basic Carlino-Mills (1987) specification to include income. The first—the traditional logic as outlined below—focuses on neoclassical migration literature. The second builds on the Roback-Blanchflower-Oswald theoretical approach to amenities and quality of life being capitalized into rents, wages, and unemployment. The third appeals to the Environmental Kuznet's Curve as outlined by Torras and Boyce (1998), Pagoulatos et al. (2004), and White and Hanink (2004). The logic is simple: at lower incomes people are willing to forego environmental quality in return for economic growth, but at some level of income people place a higher value on the environment and may be willing to forego some economic growth in the name of protecting and improving the environment. All three approaches lay solid theoretical foundations for linking amenities and quality of life to income.

(1) $$P^* = f(E^*, I^* \mid \Omega^P)$$

(2) $$E^* = g(P^*, I^* \mid \Omega^E)$$

(3) $$I^* = g(P^*, E^* \mid \Omega^I),$$

where P^*, E^*, and I^* are equilibrium levels of population, employment, and per capita income, and Ω^P, Ω^E, and Ω^I are a set of variables describing initial conditions and other historical information.[4] Contained in the latter set of information are measures of amenity attributes. This formulation expands the Carlino-Mills framework by explicitly introducing income into the structural framework.

Relying on the equilibrium conditions laid out above, a simple linear representation of those conditions can be expressed as

(4) $$P^* = \alpha_{op} + \beta_{1p}E^* + \beta_{2p}I^* + \Sigma\delta_{Ip}\Omega^P$$

(5) $$E^* = \alpha_{oE} + \beta_{1E}P^* + \beta_{2E}I^* + \Sigma\delta_{IE}\Omega^E$$

(6) $$I^* = \alpha_{oI} + \beta_{1I}P^* + \beta_{2I}E^* + \Sigma\delta_{II}\Omega^I.$$

Moreover, population, employment, and income likely adjust to their equilibrium levels with substantial lags (i.e., initial conditions). Partial adjustment equations to the equilibrium levels are

(7) $$P_t = P_{t\text{-}1} + \lambda_P\,(P^* - P_{t\text{-}1})$$

(8) $$E_t = E_{t\text{-}1} + \lambda_E\,(E^* - E_{t\text{-}1})$$

(9) $$I_t = I_{t\text{-}1} + \lambda_I\,(I^* - I_{t\text{-}1}).$$

After slight rearrangement of terms, this yields

(10) $$\Delta P = P_t - P_{t\text{-}1} = \lambda_P\,(P^* - P_{t\text{-}1})$$

(11) $$\Delta E = E_t - E_{t\text{-}1} = \lambda_E\,(E^* - E_{t\text{-}1})$$

(12) $$\Delta I = I_t - I_{t\text{-}1} = \lambda_I\,(I^* - I_{t\text{-}1}),$$

where λ_P, λ_E, and λ_I are speed of adjustment coefficients to the desired levels of population, employment, and income, respectively, which are generally positive; ΔP, ΔE, and ΔI are the region's changes in population, employment, and per capita income, respectively; and $P_{t\text{-}1}$, $E_{t\text{-}1}$, and $I_{t\text{-}1}$ are initial conditions of population, employment, and per capita income.[5] Substituting and rearranging terms allows us to express the linear representation of the model that is to be estimated as

(13) $$\Delta P = \alpha_{op} + \beta_{1p}P_{t\text{-}1} + \beta_{2p}E_{t\text{-}1} + \beta_{3p}I_{t\text{-}1} + \gamma_{1p}\Delta E + \gamma_{2p}\Delta I + \Sigma\delta_{Ip}\Omega^P$$

(14) $$\Delta E = \alpha_{oE} + \beta_{1E}P_{t\text{-}1} + \beta_{2E}E_{t\text{-}1} + \beta_{3E}I_{t\text{-}1} + \gamma_{1p}\Delta P + \gamma_{2E}\Delta I + \Sigma\delta_{IE}\Omega^E$$

(15) $$\Delta I = \alpha_{oI} + \beta_{1I}P_{t\text{-}1} + \beta_{2I}E_{t\text{-}1} + \beta_{3I}I_{t\text{-}1} + \gamma_{1I}\Delta E + \gamma_{2I}\Delta P + \Sigma\delta_{II}\Omega^I.$$

Note that the speed of adjustment coefficient (λ) becomes embedded in the linear coefficient parameters, α, β, γ, and δ. This framework is particularly useful for this analysis because it allows us to capture structural relationships while simultaneously isolating the influence of amenity attributes on regional economic growth. In essence, we are modeling short-term adjustments (i.e., ΔP, ΔE, and ΔI) to long-term equilibrium (i.e., P^*, E^*, and I^*). In this specification, ΔP, ΔE, and ΔI are the region's changes in population, employment, and per capita income, respectively; $P_{t\text{-}1}$, $E_{t\text{-}1}$, and $I_{t\text{-}1}$ are initial conditions of population, employment, and per capita income. The set of variables contained in Ω represents the characteristics of the region at the beginning of the period.

[4] One could argue that wages or earnings would be more appropriate than per capita income. If one limits the theoretical foundation for the expanded version of the traditional Carlino-Mills model along the lines of neoclassical migration theory, defining income as earnings would be appropriate. But given our focus on natural and built amenities, we suggest that the logic behind the Environmental Kuznet's Curve is more appropriate where total income is the relevant metric. A second dimension centers on the idea of retirement migration where much of the growth in these high amenity rural areas is tied directly and indirectly to retirees (Green, Deller, and Marcouiller 2005).

[5] We thank a reviewer for pointing out that stability requires that these speed of adjustment parameters should also be less than one to obtain convergence. If the parameters are negative, it is likely indicative of some type of development trap or other non-typical equilibrating process.

A Bayesian Estimator

When we think about the specification of the historical information captured in Ω^P, Ω^E, and Ω^I, theory provides a clear picture of a broad classification of variables to be considered, but fails us when we think about specific variables. Theory tells us that human capital and public fiscal policies, for example, matter, but it is less insightful when we think about specific variables to include. Herein lies a fundamental problem for those interested in identifying policy variables that can be used to help simulate growth patterns: theory does not help us define variables that are specific enough to guide policy (Bartik, Boehm, and Schlottmann 2003).

Within the large and growing empirical literature testing Solow-type neoclassical models of growth and the new breed of endogenous growth models, there is a heated debate about erroneous policy conclusions from poorly specified models.[6] Beginning with Barro and Sala-i-Martin (1992, 1995), the notion of conditional convergence has opened the floodgates of empirical studies aiming to determine which policy variables impact convergence rates [see Durlauf and Quah (1999) for a comprehensive review]. Authors such as Pack (1994), Schultz (1999), and Durlauf (2000) question much of the empirical cross-country growth literature on a range of issues, from endogeneity to measurement error, to the confusion of correlation versus causation.

Although theory fails to provide a rigorous foundation for which specific variables should be included in our set of regional characteristics (Ω^P, Ω^E, and Ω^I), some have suggested using more rigorous statistic methods, such as extreme bounds testing (Levine and Renelt 1992, Sala-i-Martin 1997) or Bayesian Model Averaging techniques (Doppelhofer, Miller, and Sala-i-Martin 2000, and Fernadez, Ley, and Steel 2001), to refine our modeling efforts. In our study of the role of amenities on rural economic growth and differences in patterns across the United States and rural Appalachia, we will follow the suggestions of Brock and Durlauf (2001) and Fernadez, Ley, and Steel (2001) and use the Bayesian Modeling Average approach.

While the probabilistic theory behind the Bayesian Modeling Average (BMA) approach is theoretically attractive, it is not necessarily intuitive. In practice, however, the BMA approach is really quite simple. In essence, all possible linear variable combinations are estimated using ordinary least squares along with corresponding coefficient standard errors. The values of the estimated coefficients and standard errors are then averaged. Variables that reach a critical threshold level are deemed to belong in the model, whereas variables that fall below that threshold are removed from the final specification of the model. Again, while the theory provides insights into structure and dynamics of economic growth, the final path and equilibrium levels are an empirical question, and the BMA provides a rigorous statistical filter for the empirics.

More formally, the Bayesian Modeling Average (BMA) is a method developed to deal with the problem of making reliable inferences about a given theoretical hypothesis, which can be based on a number of alternative statistical models presenting similar explanatory power. Model uncertainty, as this problem is often referred to in the literature, may be the result of the openendedness of the theory from which those models are built. Openendedness, as described in Brock and Durlauf (2001), is related to the idea that one causal theory does not imply the falsity of another. It may also be the result of theory contingency, sensitivity of theoretical predictions, for instance, and/or historical or geographical contexts.[7]

For linear regression models, theory openendedness can be translated into the uncertainty regarding the appropriate set of specific variables that should be included in the model, whereas theory contingency can be reduced to the uncertainty about how the values of such parameters should vary for a given sample either over time or within units of analysis. Testing a theoretical hypothesis in this case is often reduced to testing the statistical significance of variable parameters.

The conventional (and frequentist) approach has usually bypassed the issue of openendedness while totally ignoring the issue of contingency.

[6] While the bulk of this work has focused on the Solow/endogenous growth literature, the same criticism can be levied on the Carlino-Mills model, which has seen much wider application in the regional economic literature.

[7] Brock and Durlauf (2001) refer to the first type of uncertainty as theory uncertainty and to the second as heterogeneity uncertainty.

The treatment of model uncertainty has consisted of the imposition of some information criteria in order to select a single "best" model regarded as the true model from which variable parameters are estimated. Comparing determination coefficients (R^2) across alternative linear regressions with this purpose is the canonical example.

The Bayesian solution to this problem starts by assuming that each variable parameter is drawn from a distribution function conditional on the model as well as on the data set used. Based on this *prior* assumption, it then proceeds to estimate the *posterior* probability of occurrence of each model given the data set. A final estimate of the variable parameter is made by averaging its expected value over the set of all possible models weighted by each model's posterior probability of occurrence.

To clarify and formalize the BMA approach while putting it at the same time in the context of our analysis of growth determinants of Appalachian counties, consider the following linear regression model:[8]

$$(16) \qquad g_{ji} = S_j\zeta + \varepsilon_j = X_j\pi + z_j\beta_z + \varepsilon_j.$$

Equation (16) represents the reduced-form growth process as derived in the Carlino-Mills framework for the region j of counties i, with g representing any of the three county endogenous growth variables: population, employment, and per capita income. This model is described by a set of regressors, S, partitioned into a subset X and a scalar z.

The focus of the analysis is to estimate β_z, the variable coefficient that determines the role of z_j among the group of counties j. The variable z may be either individual explanatory variables such as those presented in Carlino and Mills (1987) or a specific variable in which the researcher is interested—for instance, amenities. While the Carlino-Mills framework is assertive about the set of exogenous variables that should be included, it does not rule out other variables that may influence regional growth. At the same time, there is nothing in its theoretical predictions that prevents the same structure from affecting growth differently in different parts of the country. Theory openendedness is thus represented in (16) by the researcher's uncertainty about which variables to include in the vector S, whereas theory contingency is related to uncertainty about whether variable coefficients should vary or not among the set of regions comprising all U.S. counties.

A simple way to tackle the problem of theory contingency, as shown in Brock and Durlauf (2001), is to express it in terms of the variable selection framework used to account for theory openendedness. This is done by assuming that for each variable set S, the counties under study may be split in two groups, R_A and R_B. For the purpose of our analysis, R_A would correspond to all non-metro counties located within the boundaries of the Appalachian region, with R_B representing all the remaining non-metro counties in the United States. Each of the subsets is characterized by a linear equation such as

$$(17) \qquad g_{Ai} = g_A = \beta_{zA}S_A\zeta + \varepsilon_A = X_A\pi_A + z_A\beta_{zA} + \varepsilon_A\,,\ i \in R_A$$

$$(18) \qquad g_{Bi} = g_B = S_B\zeta + \varepsilon_B = X_B\pi_B + z_B\beta_{zB} + \varepsilon_B\,,\ i \in R_B.$$

By defining δ_{jA} as a simple dummy variable which equals 1 if $i \in R_A$ and 0 otherwise, and stacking all variables in unique vector S_j, we could combine (17) and (18) back to a unique model, as in (16):

$$(19) \qquad g_{ji} = g_j = S_j\zeta + \varepsilon_j = X_j\pi_B + z_j\beta_{z,B} + X_j\ \delta_{jA}\,\pi_A + z_j\ \delta_{jA}\beta_{zA} + \varepsilon_j\ \ i \in R_j = R_A \cup R_B.$$

Theory contingency can be dealt with in this case by evaluating the likelihood of models, including X_j, δ_{jA}, and $z_j\ \delta_{jA}$ as additional variables. This procedure could be generalized to allow for multiple regions if it does not allow for the set of coefficients to vary among counties.[9] Having that in mind, assume that there exist M_m alternative models mapped on a one-to-one basis to a set of alternative variables S_{jm}, both belonging to a set Ω. The effects of any given determinant of county growth β_z should be conditional both on the

[8] Notation has been adapted from Brock and Durlauf (2001).

[9] Hierarchical Linear Models (HLM) and/or Geographically Weighted Regression (GWR) would allow for this type of structure.

model and the data set used in the analysis, and estimated accordingly.

By recognizing the existence of model uncertainty, BMA seeks to separate out the dependence of the variable parameter probability density function $\mu(\beta_z | D, M_m)$ on any particular model M_m. Estimation of each individual model is still based on frequentist estimation methods (e.g., ordinary least squares or maximum likelihood). Inferences with respect to β_z, however, are made only after its posterior distribution, given that only the observed data is calculated by the law of total probability as follows:

$$(20) \qquad \mu(\beta_z | D) = \sum_{\Omega} \mu(\beta_z | D, M_m)\, \mu(M_m | D),$$

where $\mu(M_m | D)$ denotes the posterior probability given the data of model M_m.

Using Bayes' rule, the posterior probability of model M_m can be written as a function of its priors—$\mu(M_m)$ along with the integrated likelihood of $M_m - \mu(D | M_m)$:

$$(21) \qquad \mu(M_m | D) = \frac{\mu(D | M_m)\mu(M_m)}{\sum_{\Omega}(D | M_m)\,\mu(M_m)}.$$

Plugging (21) into (20) and assuming that prior model probabilities ($\mu(M_m)$) are equal leads to

$$(22) \qquad \mu(\beta_z | D) = \sum_{\Omega} \mu(\beta_z | D, M_m) \frac{\mu(D | M_m)}{\sum_{\Omega}(D | M_m)}.$$

Based on (22), the conditional mean and standard deviation for values of β_z different than zero are shown to be

$$(23) \qquad E(\beta_z | D, \beta_z \neq 0) \approx \sum_{\Omega} b_z(M_m)\,\mu(M_m | D)$$

$$SD(\beta_z | D, \beta_z \neq 0)$$

$$\approx \sum_{\Omega} [se_z(M_m) + b^2{}_z(M_m)]$$

$$\mu(M_m | D) - E(\beta_z | D, \beta_z \neq 0)^2,$$

where $b_z(M_m)$ and $se_z(M_m)$ are the maximum likelihood estimators of the mean $E(\beta_z | D, M_m)$ and standard deviation (var $(\beta_z | D, M_m))^{.5}$ of the posterior regression parameter probability distribution function under model M_m.

This problem was originally solved in a more general framework in Leamer (1978). The approximations in (20) were derived in Raftery (1995). Raftery, Madigan, and Hoeting (1997) extended the BMA approach for linear regression models, while Brock and Durlauf (2001) introduced it into the analysis of empirical growth models.

Despite its methodological appeal, BMA analysis has not become a standard tool for the applied researcher due to the fact that its implementation presents several difficulties [see Hoeting et al. (1999) for a general overview]. Two of them have received special attention: the number of models in set Ω can be very large, making the summation in (22) operationally unfeasible, and a solution to the integral defining $\mu(D | M_m)$ is hard to compute.

In a linear regression model the maximum number of models is usually calculated by computing all possible combinations of the regressors S. This causes the size of $\Omega(n)$ to increase exponentially as a result of increases in the size of $S(s)$ ($n = 2^s$). To get around this, Madigan and Raftery (1994) and Raftery, Madigan, and Hoeting (1997) developed the idea of *Occam's window*. This principle excludes from the sum in (22) the following: (a) models that are much less likely than the most likely model by establishing a minimum criteria; and (b) models that more likely have submodels nested within them, or if model M_1 is a subset of M_0, and M_0 has been rejected, then M_1 can be readily rejected. A solution to the integral defining $\mu(D|M_m)$ was proposed by Raftery (1995). It is based on a Bayesian Information Criteria (BIC) approximation that stems from the result that for large samples the logarithm of $\mu(D | M_m)$ is equal to the maximized log-likelihood, log $\mu(D | M_{m,} \beta_z)$ minus a correction term.

All BMA calculations were performed with the program *bicreg*, which was written in SPLUS by Adrian Raftery.[10] Once the user has specified the set of variables and the dependent variable, the program generates all possible combinations on this set. All models are assumed to have equal

[10] The code we employed is available at www.research.att.com/~volinsky/bma.html.

priors, which is equivalent to saying that all variables have a 50 percent probability of being included in any model. The program then proceeds by implementing a search algorithm to explore only a subset of the model space. This search algorithm combines the Occam's window algorithm for linear regression with the BIC approximation for the μ (D | M_m) to deliver the posterior probabilities of each of the selected models given the current data set (μ (M_m | D), the posterior probabilities of each variable in set S being different than zero, along with their posterior means and standard deviations.

Amenity Indices and Base Variables

As outlined in our introductory comments, we have three focuses in this study. First, is the BMA approach a reasonable means to obtain a base model of economic growth? Second, how do amenities enter into rural economic growth? Third, is rural Appalachia sufficiently unique when compared to the whole of rural America that unique policy options can be offered? In this section we review our thinking on amenity measurement and outline the group of potential control variables entered into the BMA modeling.

Amenity Modeling

Within the literature the empirical representation of amenity attributes has tended to be single dimensional, simplistic, and to a large extent ad hoc (Gottlieb 1994). The method proposed here builds on the work of English, Marcouiller, and Cordell (2000), Wagner and Deller (1998), and Deller et al. (2001), among others. The approach we adopt was advanced by Miller (1976), who suggested that blocks of variables describing a particular attribute can be condensed into a single scalar measure that captures the information contained in the original data. For example, Dorf and Emerson (1978) reduced more than 100 different variables to 16 components that together serve as fairly reasonable predictors of each of the original variables. They then used these components to predict firm location. More recently, Henry, Barkley, and Bao (1997) compressed several blocks of variables into single regressor components to isolate the influence of local quality of life attributes on the spread effects of metropolitan growth on surrounding rural areas. Wagner and Deller (1998) use principal component analysis to compress 29 separate variables into five broad indicators of regional economic structure, which are then used as controls in a study of the influence of economic diversity on regional economic performance.

Principal component analysis is a method of compressing a set of related variables into a single scalar measure. These measures are, in essence, linear combinations of the original variables where the linear weights are the eigenvectors of the correlation matrix between the set of factor variables. Each factor is constructed orthogonal to the others. In other words, principal component analysis is a mechanical method of inspecting the sample data for directions of variability and of using this information to reduce a collection of variables into a single measure. Ideally, the final measure captures the essence of the original collection of variables. While the pros and cons of principal component analysis are well known, and a range of alternative approaches are available, we suggest that the approach used here moves the literature forward.

For this analysis we propose five broad-based indices of amenity and quality of life attributes: climate, land, water, winter recreation, and developed recreational infrastructure. We capture a region's climatic conditions such as temperature, precipitation, sunny winters, and dry summers. Developed recreational infrastructure represents a region's facilities, such as golf courses, tennis courts, swimming pools, playgrounds, and significant historical and cultural dimensions. In the set of land variables, we want to capture a region's land resources, such as the percentage of acres included in federal wilderness areas, forestland, farmland, and state park land. The set of water variables account for the region's wealth of water resources, including the percentage of the county's land area comprised of river, lakes, and bays, and associated resources for recreational activities such as canoeing, diving, and fishing. Finally, in the set of winter variables, we try to capture the region's winter ski facilities and activities. We limit the current analysis to six variables to represent a region's climatic conditions, thirteen variables to portray developed recreational infrastructure, sixteen to represent land resources, twelve to depict water resources, and six to represent winter facilities.[11]

To do this we use the National Outdoor Recreation Supply Information System (NORSIS) data set developed and maintained by the USDA Forest Service's Southern Research Station, located in Athens, Georgia. As an outflow of the 1998 Resource Planning Act Assessment of Outdoor Recreation and Wilderness, the Forest Service maintains an extensive county-level data set documenting facilities and resources that support outdoor recreation activities. Many of these same resources are precisely the amenities that contribute to the overall quality of life of the region. The NORSIS data set contains over three hundred separate variables ranging from population density, the proportion of county acres in each cropland, forest, pasture/range land, mountains and water surface, and employment and income levels in recreational industries, to the number of public libraries for the year 1997.

While the approach used here is superior to the simplistic single dimensional measures such as number of sunny days or the crime rate as used originally by Graves (1979, 1980, 1983), Roback (1982, 1988), and Carlino and Mills (1987), or the numerically calculated index such as those constructed by Nord and Cromartie (1997) or McGranahan (1999), it is not without its limitations. First and foremost is the breadth of the individual factor scales. In the five amenity measures used in this analysis, the breadth runs from six input variables for the winter amenity to 16 input variables for the land amenity. Why 16 for the land amenity index and not four or five or 26 input measures? Why this particular combination and not another? There are no clear or ready answers to these simple questions. Data availability and researcher discretion seem to be the primary determinants with this approach.

Clearly, the more comprehensive we attempt to make the principal component analysis, the greater the variability of the collection of inputs that a single component can capture. This explains why the explanatory power (cumulative variance explained) declines as the number of input variables increases. Perhaps the amenity measures to be examined need to be more narrowly defined, and the breadth, or number of input variables, of each factor scale can be narrowed. At the extreme, however, we reduce the problem back to a single dimensional measure. How do we determine the balance between too many input variables and not enough?

A second problem is the arbitrary selection of principal component analysis as the specific factor reduction method used for this study. As already noted, we arbitrarily narrowed our focus on the first principal component while ignoring higher-order components rather than using the Kaiser criterion or screen test. Should we use oblique or orthogonal factors when building components or perhaps hierarchical factor analysis with clusters? The number of possible ways to build our principal components is yet another complicating issue.

A third problem is how to interpret our final measures of amenities. By statistically merging single dimensional measures, we lose insights into specific policy interpretations. If, for example, the modeling effort finds that more highly developed recreational infrastructure is associated with faster rates of growth in population, employment, and income, what is the specific policy recommendation that follows? By moving to broader measures of amenities, we lose insights into specific policy suggestions.

The results of the principal component analysis for the five broad measures of amenity attributes are reported in Tables 1 through 5. For climate (Table 1), the final measure accounts for 46.2 percent of the variation of the six separate input

Table 1. Principal Component Eigenvectors: Climate

Climate Variables	Eigenvector
Average temperature	0.5016
Average annual precipitation	0.5387
January temperature	0.5160
January sunny days	0.0391
July temperature	0.0747
July humidity	0.4300
Cumulative variance explained	46.17 %

[11] The selection of a specific principal component relies on three rules of thumb. One rule suggests that one should choose the first principal component. This is because the first principal component is the best summary of the entire data set, for it accounts for the most total variance in the correlation matrix across all of the variables. The second rule of thumb selects the principal components that have eigenvalues of the correlation matrix greater than one. The third approach is to use every principal component that is generated. In the research we have elected to use the first selection criteria.

Table 2. Principal Component Eigenvectors: Developed Recreational Infrastructure

Urban Facilities Variables	Eigenvector
Number of parks and recreational departments	0.4168
Number of tour operators and sightseeing tour operators	0.2884
Number of playgrounds and recreation centers	0.0187
Number of private and public swimming pools	0.0785
Number of private and public tennis courts	0.4950
Number of organized camps	0.2739
Number of tourist attractions and historical places	0.1559
Number of amusement places	0.3534
Number of fairgrounds	0.0035
Number of local or county parks	0.0313
Number of private and public golf courses	0.3908
Number of ISTEA[a]-funded greenway trails	0.3300
1995 National Resources Inventory (NRI): estimated number of acres of urban and built-up land	0.0680
Cumulative variance explained	16.69 %

[a] Intermodal Surface Transportation Efficiency Act.

Table 3. Principal Component Eigenvectors: Land

Land Variables	Eigenvector
Number of guide services	0.3186
Number of hunting/fishing preserves, clubs, lodges	-0.0276
Bureau of Land Management: public domain acres	0.1593
Acres of mountains	0.4021
Acres of cropland, pasture, and range land	-0.3403
USDA Forest Service: national forest and grassland acres	0.4495
U.S. Fish and Wildlife Service: refuge acres open for recreation	0.1129
Woodalls: number of private campground sites	0.2983
Woodalls: number of public campground sites	0.1449
National Park Service federal acres	0.2617
National Resources Inventory: estimate of forest acres	0.0981
Acres managed by Bureau of Reclamation, Tennessee Valley Authority, Corps of Engineers	0.0014
Total rail-trail miles	0.0993
State park acres	0.0420
Nature Conservancy acres with public access	0.0231
National Wilderness Preservation System acreage: total 1993	0.4240
Cumulative variance explained	18.72 %

variables. Of the six variables, only January sunny days and July temperature do not play an important role in the final measure. Counties that have higher average winter and year-round temperatures and precipitation levels, as well as higher levels of July humidity, tend to have higher values of the final principal component measure. Higher values of the climate measure tend to be associated with southern coastal regions such as Alabama and Florida, while lower values tend to be associated with more northern regions such as Maine and Wyoming. Based on the cumulative variance of all six variables explained by the final measure, the climate measure has the strongest performance, accounting for 46.2 percent of the variation.

The developed recreational infrastructure measure is intended to capture the role of amenities

Table 4. Principal Component Eigenvectors: Water

Water Variables	Eigenvector
Number of marinas	0.4219
Number of canoe outfitters, rental firms, and raft trip firms	0.3269
Number of diving instruction or tours and snorkel outfitters	0.1908
Number of guide services	0.4776
Number of fish camps, private or public fish lakes, piers, and ponds	0.5482
American Whitewater Association total whitewater river miles	0.1184
Designated Wild and Scenic River miles: total 1993	0.1367
National Resources Inventory (NRI) acres in water bodies: 2–40 acres, < 2 acres, and ≥ 40 acres (lake or reservoir)	0.1597
NRI acres in streams < 66′ wide, 66–660′ wide, and ≥ 1/8 miles wide	-0.0364
NRI water body ≥ 40 acres (bay, gulf, or estuary)	0.2665
NRI wetland acres	0.0654
NRI total river miles, outstanding value	0.1235
Cumulative variance explained	16.84 %

Table 5. Principal Component Eigenvectors: Winter

Winter Variables	Eigenvector
Cross-Country Ski Areas Association: number of cross-country ski firms and public cross-country ski centers	0.3496
International Ski Service: skiable acreage	0.3206
Federal land acres in counties with > 24″ annual snowfall	0.5233
Agricultural acres in counties with > 24″ annual snowfall	0.1381
Acres of mountains in counties > 24″ annual snowfall	0.5864
Acres of forestland in counties > 24″ annual snowfall	0.3717
Cumulative variance explained	35.93 %

that tend to be more artificial, or human-built (Table 2). Fourteen separate variables are used to construct this particular amenity attribute measure. Individual variables that determine the final amenity measure include the number of park and recreational departments within the county, the number of tennis courts, the number of establishments defined as amusement in orientation, and the number of golf courses. The number of swimming pools, playgrounds, and recreational centers and fairgrounds does not contribute significantly to the final developed recreational infrastructure measure of amenities. The central sands region of North Carolina, for example, which is the location of numerous golfing communities such as Pinehurst, scores highly on this amenity measure. Given the nature of most of rural America, the majority of counties score rather low on this measure. Due to the relatively large number of variables introduced into this measure, coupled with the large number of variables not loading (entering) into the final principal component measure, only 16.7 percent of the cumulative variance is explained.

The land measure is intended to describe the nature of the terrain and land resources within the county (Table 3). The principal component derived final measure appears to separate mountainous areas that have high levels of National Forest and Grassland acres and federally designated Wilderness acreage from those that tend to be more agriculturally oriented. Given these results, counties from the western states would tend to score higher on this measure, while lands in the Corn Belt or Great Plains would tend to score lower. Again, due to the relatively large number of variables introduced into this measure, coupled with the large number of variables not loading into the final principal component measure, only 18.7 percent of the cumulative variance is explained.

The water measure is intended to capture the water resources available within the county (Table 4). The final principal component measure used for this analysis tends to emphasize value-added businesses associated with water resources. Counties with a higher number of marinas, guide services, businesses that cater to fishing activities, and canoe or rafting rental firms tend to score higher on this measure. Counties with undeveloped, pure water resources do not appear to rank high in this measure. This measure captures water resources that are more highly developed for recreational uses. The Ozark region of Missouri tends to score high on this measure, while more pristine regions such as the boundary waters of Minnesota tend to score lower. Arid places such as eastern Colorado score the lowest on this measure. As with the developed recreational infrastructure and land measures, the large number of variables introduced into the analysis reduced the cumulative variation explained to 16.8 percent.

The fifth and final measure of amenity attributes used in this analysis captures winter recreational opportunities (Table 5). Results strongly separate counties with developed commercial facilities, both downhill and cross-country skiing, from areas with limited snowfall or those areas with snowfall that are not developed. This principal component measure is separating winter recreational destination areas, such as Teton County, Wyoming, from all others. The cumulative variation explained is 35.9 percent.

The measures as defined by the principal component analysis appear to be identifying those counties that tend to have reasonably high levels of recreational development combined with an amenity base as opposed to those areas that have solely higher levels of raw amenities. The interpretation of the empirical results in the next section must be sensitive to the fact that the measures developed here tend to capture many of the areas with more highly developed amenities. Remote counties with pristine lakes and untouched wilderness will tend to score lower on several of our measures than would similar counties with more highly developed areas. Moreover, remote areas with lakes, forests, and non-flat terrain will score higher in these measures than remote flatlands regardless of the level of commercial development. One possible explanation for this pattern is the relative homogeneity of most rural counties. Rural counties with high amenities are more commercially developed and so tend to stand out in a statistical sense. From a regional growth perspective, there may be mild agglomeration effects that exist with respect to recreational facility development in rural counties.

Base Model Variable Definitions

We begin the construction of our base model with 69 potential control variables within ten broad areas including historical, markets to proxy demand, labor to proxy supply, financial market, public infrastructure, government taxation and services, economic structure, agglomeration potential, geographic location, and politics (see Appendix). In constructing these groupings of potential control variables, we are building on the logic of Duffy (1994), Wagner and Deller (1998), and Deller et al. (2001). The broad categories of potential control variables include historical and within our modeling framework are the base year values of employment, population, and income. The market category is intended to capture the demand structure of local markets and is designed to capture factors that affect the region's ability to buy (measures of income, wealth, and inequality), taste, and preferences (such as age and racial profiles). Labor is intended to capture the ability of the regional market to supply the goods and services needed for local and export markets. The supply side of the market is proxied by a range of variables including education levels, access to health care, and crime rates.

Based on the summary work of Kusmin (1994), other broad categories included in the analysis are measures of credit availability, utility infrastructure, and public fiscal policies. Economic structure is also included, along with measures of agglomeration (proximity to metro and population density) and political preferences. Because we cannot explicitly model spatial relationships in our BMA approach, we include the latitude and longitude of the county. We also include a simple dummy identifier for Appalachian counties in the core model to allow for the BMA approach to independently select out Appalachia. If Appalachia is sufficiently different from the rest of the United States, the BMA should find that the simple dummy variable is important in explaining changes in population, employment, and income.

Within each of these broad categories there not only are numerous ways to measure the desired characteristics, such as economic structure, but there is controversy in terms of how the characteristics influence growth. Consider, for example, the fiscal policies of local governments within the economic growth; this literature is itself vast and controversial (Lynch 2004). In a review of the literature, Ladd (1998) argues that this particular strand of the growth literature has gone through several phases and that there is little if any agreement in terms of how fiscal policies should be measured or in terms of their influence on economic growth.

Because so many of the potential control variables included in the original list of 69 could be considered proxies for each other, we use simple correlation coefficients to par down our list of 69. In the labor sub-category of education, we have seven potential measures of education, ranging from percentage of the population over age 25 with a high school or college education to number of high school dropouts. If more than two variables within a sub-grouping are highly correlated, we can filter, or reduce, the number of potential variables to be included in the Bayesian. For example, in the crime sub-grouping we have eleven separate crime measures drawn from FBI statistics. All of these variables were highly correlated. The variable "total crimes per one thousand persons" seems to mirror all the statistical information contained in the more detailed crime data.

Modeling Results

To test our simple hypotheses outlined in detail above, we focus our attention on data from 2,242 non-metropolitan U.S. counties, including the 290 rural Appalachian counties for the period 1989 to 1999. To simplify our estimation we applied Bayesian Modeling Average to the reduced forms of our growth equations represented in (13), (14), and (15). To answer our basic research questions about rural Appalachia and the role of amenities in economic growth, we move this research forward in three steps. First, using the national data set we employ the BMA method to derive a base growth model. Within this step we include an Appalachia identifier and allow the BMA method to determine if Appalachia behaves differently from the rest of the United States (Model A). Once the base model is determined, we introduce our five measures of amenities (Model B). The second step introduces a set of slope-shifter dummy variables where we allow each variable coefficient to differ for Appalachian counties. This allows us to tell not only if rural Appalachia behaves differently from the rest of rural America, but in what specific ways (Models C and D). The third step re-estimates the base model, with and without the amenity measures, using only data for rural Appalachia (Models E and F). Using this step approach we can identify specific patterns in which rural Appalachia differs from the rest of the United States.

BMA Derived Base Model (Model A)

Using simple correlation coefficients, we condensed the original list of 69 variables down to 30 to be introduced into the Bayesian estimator. For the population equation, the BMA approach yielded 15 variables (Table 6), 14 variables for the employment equation (Table 7), and 14 variables for the per capita income equation (Table 8). It is important to note that the simple Appalachia identifier variables were drawn into only employment growth. Based on the Bayesian estimator, rural Appalachia growth patterns in population and per capita income are no different than the rest of rural America for the period examined (1989–1999). The results do suggest that employment growth in rural Appalachia was significantly slower during the 1990s than in the rest of the United States.

Focus first on the *population growth* equation (Table 6).[12] In general, the population growth equation performs well, explaining 57.5 percent of the variation in growth. Of the 15 variables that comprise the base model, five have a positive influence on population growth, including historical growth patterns in population, employment

[12] In all cases growth is defined as a percentage of growth rate: $(y_t - y_{t-1}) / y_{t-1}$.

Table 6. Growth in Population (1989–1999)

	Model A	Model B	Model C	Model D	Model E	Model F
Intercept	-14.1317	-14.3001	N/A	N/A	-48.8196	-56.3764
	(3.91)	(3.98)			(3.57)	(2.78)
Change in per capita income, 1979–1989	0.0702	0.0640	0.0052	-0.0271	0.0798	0.0872
	(5.19)	(4.79)	(0.09)	(0.43)	(2.00)	(2.07)
Change in employment, 1979–1989	0.0710	0.0438	-0.0885	-0.0339	-0.0142	-0.0164
	(4.15)	(2.56)	(1.70)	(0.65)	(0.48)	(0.55)
Change in population, 1979–1989	0.5491	0.5498	0.3009	0.2461	0.8397	0.8464
	(21.96)	(22.00)	(3.62)	(2.83)	(16.22)	(15.86)
Percentage of the population non-white	-0.0575	-0.0562	-0.0437	-0.0732	-0.1640	-0.1557
	(3.62)	(3.43)	(0.83)	(1.18)	(3.96)	(3.47)
Percentage of the population over age 65	-0.3453	-0.3122	0.3167	0.3702	0.0278	0.0342
	(5.98)	(5.26)	(1.46)	(1.61)	(0.16)	(0.18)
Percentage of families living in poverty	0.0752	0.1179	0.0028	-0.0483	0.1119	0.1329
	(1.83)	(2.83)	(0.03)	(0.53)	(1.30)	(1.45)
Number of vehicles per household	10.9848	12.4051	-5.6497	-6.8914	8.0956	8.9982
	(6.61)	(7.52)	(2.33)	(2.61)	(2.14)	(2.25)
Percentage of population living on farms	-0.2877	-0.2193	0.3671	0.3507	-0.0366	-0.0601
	(7.78)	(5.57)	(2.47)	(2.24)	(0.34)	(0.52)
Percentage of population foreign-born	-0.2202	-0.1529	-0.4945	-0.1980	-0.7761	-0.8694
	(2.54)	(1.78)	(0.53)	(0.21)	(1.26)	(1.38)
Local taxes per capita	-0.0043	-0.0059	0.0034	0.0084	0.0019	0.0010
	(6.51)	(8.50)	(0.79)	(1.73)	(0.63)	(0.32)
State/local govt. employment per 10K pop.	-0.0053	-0.0048	0.0022	0.0017	-0.0031	-0.0029
	(6.57)	(6.03)	(0.73)	(0.57)	(1.52)	(1.38)
Federal civilian employment per 10K pop.	-0.0005	-0.0023	0.0070	0.0087	0.0025	0.0023
	(0.41)	(1.74)	(1.19)	(1.48)	(0.70)	(0.63)
Federal military employment per 10K pop.	-0.0015	-0.0014	0.0001	0.0002	-0.0009	-0.0009
	(6.17)	(5.69)	(0.03)	(0.05)	(1.34)	(1.32)
Population density	-9.6474	-5.7304	12.9748	7.9158	-0.1003	0.2299
	(1.66)	(0.99)	(0.81)	(0.48)	(0.02)	(0.05)
Appalachia identifier	N/A	N/A	N/A	N/A	N/A	N/A
Longitude	0.1318	0.0937	0.3930	0.3835	0.4918	0.5649
	(5.27)	(3.59)	(3.76)	(3.20)	(2.81)	(2.39)
Climate characteristic index	--	0.2765	--	0.7475	--	-0.4331
		(1.62)		(0.75)		(0.56)
Land characteristic index	--	-0.1948	--	0.8021	--	-0.1791
		(0.98)		(1.26)		(0.45)
Water characteristic index	--	0.7155	--	-1.0204	--	0.0998
		(4.23)		(0.96)		(0.17)
Winter characteristic index	--	1.0844	--	-2.0469	--	0.1379
		(4.94)		(3.54)		(0.44)
Urban or built amenity characteristic index	--	0.4249	--	-0.2681	--	0.2114
		(2.85)		(0.24)		(0.63)
Equation *F* statistic	200.22	160.39	105.04	84.55	89.90	66.77
Adjusted *R* square	0.5752	0.5909	0.5775	0.5962	0.7692	0.7668
Sample size	2,242	2,242	2,242	2,242	290	290

Notes: Model A is base all U.S. / Model B is amenity-augmented U.S. / Model C is base Appalachia slope. / Model D is amenity-augmented Appalachia slope. / Model E is base Appalachia. / Model F is amenity-augmented Appalachia.

Table 7. Growth in Employment (1989–1999)

	Model A	Model B	Model C	Model D	Model E	Model F
Intercept	14.9941	19.5537	N/A	N/A	-24.6967	-86.9486
	(2.34)	(2.96)			(0.98)	(2.42)
Change in employment, 1979–1989	0.0565	0.0151	-0.0828	-0.0372	0.0323	0.0276
	(1.67)	(0.44)	(0.89)	(0.39)	(0.64)	(0.55)
Change in population, 1979–1989	0.5335	0.5514	0.5216	0.4395	0.9197	0.9203
	(10.67)	(10.90)	(2.93)	(2.40)	(9.58)	(9.52)
% of the population non-white	-0.083	-0.0407	-0.1331	-0.1056	-0.2664	-0.1678
	(2.63)	(1.20)	(1.23)	(0.77)	(3.51)	(2.03)
% of the population over age 65	-0.4398	-0.4058	0.6857	0.3695	0.1267	-0.1224
	(3.85)	(3.48)	(1.45)	(0.74)	(0.46)	(0.42)
% of the population with a bachelor's degree	0.7613	0.4828	-0.3550	-0.0334	0.7402	0.6214
	(7.16)	(4.25)	(0.71)	(0.06)	(2.97)	(2.49)
Number of vehicles per household	-4.3621	-3.5537	-1.2633	-0.4199	-6.2832	-3.6229
	(1.66)	(1.31)	(0.14)	(0.04)	(1.23)	(0.69)
% of the population foreign-born	-0.8135	-0.6510	-2.2752	-2.8379	-4.5176	-4.0771
	(4.53)	(3.63)	(0.92)	(1.13)	(3.34)	(3.03)
Local taxes per capita	-0.0067	-0.0097	-0.0058	-0.0023	-0.0044	-0.0078
	(4.81)	(6.64)	(0.68)	(0.23)	(0.78)	(1.34)
State/local govt. employment per 10K pop.	-0.0083	-0.0061	0.0067	0.0023	-0.0043	-0.0045
	(4.66)	(3.40)	(0.91)	(0.32)	(1.03)	(1.08)
Federal civilian employment per 10K pop.	-0.0042	-0.0078	0.0001	0.0003	-0.0092	-0.0125
	(1.55)	(2.84)	(0.00)	(0.02)	(1.36)	(1.85)
Federal military employment per 10K pop.	-0.0023	-0.0021	-0.0006	0.0001	-0.0008	-0.0007
	(4.58)	(4.12)	(0.08)	(0.01)	(0.61)	(0.57)
Population density	-32.8354	-27.7530	42.2743	49.9961	4.1763	7.1633
	(2.72)	(2.30)	(1.23)	(1.41)	(0.55)	(0.94)
Appalachia identifier	-2.4681	-2.2747	-8.8970	-9.5693	N/A	N/A
	(1.86)	(1.67)	(0.52)	(0.51)		
Longitudinal coordinates	0.2363	0.1971	0.3485	0.6430	0.6120	1.3833
	(4.48)	(3.69)	(3.40)	(3.54)	(2.02)	(3.31)
Climate characteristic index	--	-0.8239	--	-0.2284	--	-3.6026
		(2.35)		(0.11)		(2.70)
Land characteristic index	--	-0.2243	--	2.6384	--	1.7901
		(0.53)		(2.00)		(2.50)
Water characteristic index	--	1.4559	--	-0.4464	--	0.6654
		(4.02)		(0.20)		(0.61)
Winter characteristic index	--	0.3472	--	-1.8679	--	-0.2262
		(0.75)		(1.53)		(0.39)
Urban or built amenity characteristic index	--	1.3056	--	-1.1564	--	0.4337
		(4.09)		(0.63)		(0.70)
Equation *F* statistic	46.25	38.19	25.72	20.88	32.79	25.37
Adjusted *R* square	0.2230	0.2425	0.2255	0.2448	0.5081	0.5230
Sample size	2,242	2,242	2,242	2,242	290	290

Notes: Model A is base all U.S. / Model B is amenity-augmented U.S. / Model C is base Appalachia slope. / Model D is amenity-augmented Appalachia slope. / Model E is base Appalachia. / Model F is amenity-augmented Appalachia.

Table 8. Growth in Per Capita Income (1989–1999)

	Model A	Model B	Model C	Model D	Model E	Model F
Intercept	45.0593	45.5276	N/A	N/A	31.5671	24.2269
	(10.59)	(9.90)			(3.56)	(2.42)
Change in population, 1979–1989	-0.0429	-0.0489	0.1234	0.0649	0.0643	0.0140
	(2.09)	(2.21)	(1.71)	(0.80)	(1.90)	(0.38)
Per capita income, 1989	-0.0007	-0.0007	-0.0004	-0.0004	-0.0007	-0.0004
	(7.34)	(7.45)	(1.16)	(1.12)	(2.54)	(1.68)
Employment, 1989	0.0003	0.0003	-0.0001	-0.0001	-0.0001	-0.0001
	(3.53)	(3.39)	(0.34)	(0.35)	(0.07)	(0.96)
Population, 1989	-0.0002	-0.0001	0.0001	0.0001	0.0001	0.0001
	(3.48)	(3.38)	(0.36)	(0.58)	(0.39)	(1.29)
Income distribution	0.0029	0.0029	-0.0011	-0.0010	0.0035	0.0041
	(3.35)	(3.26)	(0.72)	(0.64)	(2.08)	(2.43)
Unemployment rate	-0.5424	-0.5457	-0.0854	-0.0624	-0.5190	-0.4661
	(6.94)	(6.76)	(0.37)	(0.27)	(3.72)	(3.30)
% of the population with a high school degree	-0.3049	-0.3059	0.0514	0.0787	-0.2482	-0.1847
	(7.92)	(6.64)	(0.42)	(0.57)	(3.06)	(1.84)
% of the population with a bachelor's degree	0.6394	0.6259	-0.0381	-0.1324	0.6834	0.5576
	(8.69)	(8.30)	(0.13)	(0.43)	(4.18)	(3.25)
% of houses with natural gas	0.0381	0.0427	-0.0552	-0.0161	-0.0023	0.0242
	(3.91)	(3.94)	(1.72)	(0.44)	(0.13)	(1.16)
Death rate	-0.4305	-0.4377	0.7863	0.4501	0.2051	-0.1417
	(4.36)	(4.32)	(1.68)	(0.92)	(0.75)	(0.49)
% of the population living on farms	-0.2044	-0.1931	-0.0871	0.1312	-0.1568	0.0253
	(5.31)	(4.48)	(0.51)	(0.68)	(1.42)	(0.21)
% of the population foreign-born	-0.5892	-0.5770	-0.9995	-0.8876	-2.1599	-1.6508
	(6.53)	(6.34)	(0.75)	(0.64)	(3.04)	(2.25)
Local taxes per capita	0.003	0.0028	-0.0001	-0.0001	0.0024	0.0022
	(3.79)	(3.40)	(0.00)	(0.01)	(0.74)	(0.65)
State/local govt. employment per 10K pop.	-0.0028	-0.0027	0.0031	0.0022	-0.0008	-0.0013
	(2.88)	(2.74)	(0.77)	(0.54)	(0.34)	(0.58)
Appalachia identifier	N/A	N/A	N/A	N/A	N/A	N/A
Climate characteristic index	--	-0.0337	--	0.7287	--	0.6263
		(0.17)		(0.77)		(1.05)
Land characteristic index	--	0.1506	--	1.3694	--	1.3189
		(0.67)		(1.79)		(3.22)
Water characteristic index	--	0.2095	--	0.2944	--	0.7900
		(1.09)		(0.24)		(1.34)
Winter characteristic index	--	-0.2503	--	-0.0710	--	-0.4253
		(0.98)		(0.10)		(1.34)
Urban or built amenity characteristic index	--	0.1586	--	1.0418	--	0.0311
		(0.98)		(0.79)		(0.09)
Equation *F* statistic	37.25	27.71	19.08	14.38	10.25	8.91
Adjusted *R* square	0.1870	0.1869	0.1866	0.1872	0.2445	0.2730
Sample size	2,242	2,242	2,242	2,242	290	290

Notes: Model A is base all U.S. / Model B is amenity-augmented U.S. / Model C is base Appalachia slope. / Model D is amenity-augmented Appalachia slope. / Model E is base Appalachia. / Model F is amenity-augmented Appalachia.

and per capita income, percentage of families living in poverty, and number of vehicles per household. The results on historical growth patterns make intuitive sense and are consistent with regional growth theory: areas that experienced growth during the 1980s tended to continue that growth through the 1990s, with growth in population having the strongest influence on continued population growth. It is also of interest to note that the simple longitudinal location of the county in the United States helps explain growth patterns. As the location of a rural county moves west, the predicted level of population growth increases. This is not surprising given the rapid growth of rural counties in many of the western states.

The nine remaining variables tend to have a dampening effect on population growth, including percentage of the population that is non-white, a higher percentage of the population over age 65, as well as a higher percentage of the population living on farms, or being foreign-born. In addition, higher local tax levels along with greater dependency on the public sector for employment tend to place downward pressure on population growth. Surprisingly, higher population densities tend to have a negative impact on population growth. This is not consistent with traditional regional growth theory, which suggests that more urban areas, as proxied by population density, tend to have a growth advantage over more rural areas. This conclusion is, however, consistent with the central hypothesis that people are seeking out high amenity areas that are not congested. But care must be taken because the result is statistically weak, and when we move to more complete specifications of the model, population density becomes consistently insignificant.

The *employment growth* equation explained 22.3 percent of the variation in dependent variables (Table 7). The BMA method reveals that historical growth patterns in employment and population had a strong positive impact on growth in employment during the 1990s. Historical growth in per capita income, however, does not influence employment growth. Inconsistent with the initial hypothesis of Carlino-Mills, initial base levels of population, employment, and per capita income do not seem to influence employment growth. Of the remaining twelve variables introduced into the employment growth equation, only two have a positive influence on employment growth: percentage of the population with a bachelor's degree and the longitudinal location of the county—specifically, the more western the location of the county, the faster the employment growth.

Ten of the fourteen variables identified by the Bayesian method have a dampening or negative effect on employment growth. These include percentage of the population that is non-white or over the age of 65, number of vehicles per household, percentage of the population that is foreign-born, local tax levels, and dependency on the government for employment. Like the population equation discussed above, higher levels of population density also have a dampening effect on employment growth, something that is unexpected given the current thinking in endogenous growth theory.

Perhaps most important for this research, the Appalachia identifier variable is recognized by the BMA method as having a statistically significant but negative effect on employment growth. The direct interpretation of this result suggests that rural Appalachian counties, holding all else constant, experienced lower levels of employment growth during the 1990s. In other words, once other relevant socioeconomic variables are controlled for, rural Appalachia lagged behind the rest of rural America with respect to job growth.

The *per capita income growth* results are presented in Table 8. Unlike the population and employment equation, only historical growth patterns in population influenced income growth in the 1990s, but in a negative direction: rural counties that experienced higher levels of population growth in the 1980s had lower levels of growth in per capita income in the 1990s. Again, unlike the employment equation, initial levels of population, employment, and income do have an impact on income growth, but in mixed ways. Higher levels of initial employment tended to have a positive impact on income growth, but higher initial levels of population and per capita income tended to have a negative impact on income growth.[13]

[13] The result with respect to initial levels of per capita income is consistent with neoclassical growth theory, in which regional incomes will tend to converge over time to a national average.

The BMA method identified ten variables as having a statistically significant impact on rural county income growth patterns beyond the historical growth and initial level variables. Four of those ten variables had a positive impact on income growth, including percentage of population with a bachelor's degree, percentage of houses with natural gas, and local taxes per capita. While the result on education levels makes sense, the latter two results are less intuitive. Recall that the natural gas variable is intended to reflect regional investments in infrastructure. This result suggests that rural areas that invest in natural gas as an energy source may be promoting higher-end growth as captured by per capita income. If higher local taxes can be equated with higher levels of local public services such as police and fire protection, quality public schools, and better access to public recreational facilities like parks, then these services tend to also promote higher-end growth. In addition, higher levels of income inequality, as measured by a simple entropy measure of income distribution, have a positive impact on income growth. This is an important conclusion and will be elaborated upon later in our discussion.

Rural counties that have higher initial unemployment rates, percentage of the population with a high school diploma, death rates, and percentage of the population living on farms, as well as the percentage foreign-born, have a negative impact on per capita income growth rates. In addition, higher dependency on state and local government for employment opportunities tends to dampen income growth levels.[14] Like the population equation, the BMA method did not separate out rural Appalachian counties as being different from the rest of rural America with respect to per capita income growth.

BMA Base Model Augmented with Amenities (Model B)

To test our hypothesis on the role of amenities on economic growth, we introduce our five amenity indices into our BMA-derived base model (Model B). Consider first the population growth equation where only the land amenity measure does not appear to influence growth (Table 6). The climate index has a weak positive impact on population growth, suggesting that rural areas that can be characterized as having warmer, sunnier weather tend to experience more population growth than colder rural regions. Rural regions that have access to more variety of water resources such as coastal areas and those inland areas endowed with lakes and rivers also have higher levels of population growth. Keep in mind, however, that the water amenity index tends to favor water resources that tend to have more recreational potential than undeveloped water resources. Having higher levels of winter amenities, particularly mountainous areas with significant snowfall, also tends to have a positive influence on population growth levels. Finally, having more urban or built amenities, including such things as public parks and recreation departments as well as tennis courts and golf courses, has a significant positive impact on population growth. It is important to note that none of the BMA-derived base variable results are altered by introducing our amenity indices, lending buoyancy to our results.

Turning attention to the employment growth equation, we see a slightly different set of amenity results (Table 7). Unlike the population equation, the introduction of amenity measures reduces the statistical significance of employment historical growth, percentage of the population that is non-white, and the number of vehicles per household. More importantly, the introduction of the amenity variables reduces the statistical significance of the already weak result on the Appalachian county identifier. Of the five amenity measures, the indices for land and winter characteristics are not statistically significant. Unlike population, the climate measure actually has a significant negative association with employment growth. This result is somewhat surprising. Both the water and urban or built amenity indices have a positive and statistically significant impact on employment growth.

Finally, the results of the income growth equation are the most surprising (Table 8). While the introduction of the amenity measures did not alter the basic results of the BMA-derived base model, none of the amenity measures appear to have any statistically significant influence on per capita income growth. On the other hand, if the logic of

[14] One should keep in mind that public employment shares and local taxes are not proxies for each other and are indeed measuring different dimensions of the public sector.

Roback is correct, people may be willing to relocate to amenity areas independent of income levels. In addition, if many of the people moving into high amenity areas are retirees, then it may be reasonable to expect income to be unaffected. Work by Shields, Stallmann, and Deller (1999) suggests that the nature of the migrating retirees is complex and that it is difficult to draw broad generalizations.

BMA Base Model With Appalachia Identifiers (Models C and D)

As described above, to test for differences across rural Appalachia and the rest of the United States, we introduced a simple Appalachia identifier variable into the BMA modeling as well as introduced a series of slope shifters. The latter are reported in Models C and D, where Model C is the BMA base model and Model D is the amenity-augmented base model. For space consideration we report on the slope shift coefficients themselves.

When examining the slope coefficients we are looking for three things: overall statistical significance, general direction of the coefficient (negative and/or positive), and magnitude of the coefficient. If the slope shifter coefficient is statistically significant, then we can conclude that rural Appalachia behaves differently than the rest of rural America with respect to that particular variable. If the slope shifter is statistically significant, then we consider the sign and magnitude of the coefficient. If the coefficient is the same sign as the base variable, this means that the effect that the variable of interest has on growth is stronger for rural Appalachia than for the rest of the United States. If the coefficient is of the opposite sign, then the effect of the variable on growth is weaker than for the rest of the United States. Indeed, if the coefficient is of the opposite sign and sufficiently large, then the effect of that variable on growth is the opposite of the results of the base model for rural Appalachia.

First, consider the BMA base *population growth* equation (Model C, Table 6). Of the fifteen variables in the BMA base population equation, five are statistically different for rural Appalachia. Historical growth in employment has a much weaker impact on rural Appalachia population growth than on the rest of the United States. The negative slope coefficient is about equal in size and opposite in sign than in the base model, implying that for rural Appalachia there may be no effect for this variable. Historical growth in population, however, has a much stronger positive impact on population growth in rural Appalachia. The positive and statistically significant coefficient is added to the base model coefficient, resulting in an even larger positive coefficient. The slope shift coefficient on number of vehicles per household is negative, but not sufficiently large—suggesting that the number of vehicles is still positively associated with population growth, but not as strongly in rural Appalachia. Unlike most of rural America, the percentage of the population living on farms appears to have a positive influence on population growth in rural Appalachia. Finally, the slope shift variable attached to the longitude of the county is positive, suggesting that the further west the rural Appalachian county, the stronger the growth in population. It is important to note that for the remaining nine variables, rural Appalachia does not appear to be sufficiently different from the rest of rural America.

For the amenity-augmented population growth model, the pattern of base model variables remains the same with a few exceptions (Model D, Table 6). First, the Appalachia slope coefficient on the percentage of the population that is over age 65 is statistically significant, although at a reduced level of confidence. Here, the positive coefficient, viewed in light of the base model parameter, suggests that areas in rural Appalachia with an older population may experience slightly faster population growth than the rest of the United States. Second, local taxes per capita also appear to have a different impact on population growth rates in rural Appalachia than they do in the rest of rural America, although again at a weaker level of statistical significance. With respect to the amenity indices, four of the five rural Appalachia slope coefficients are not statistically significant at any reasonable level of confidence. The fifth index, however—winter characteristics—is statistically different. The negative coefficient on winter amenities is sufficiently large to suggest that considerable snowfall in rural Appalachia is a deterrent to population growth.

Turning attention to the *employment growth* model, only two Appalachia slope coefficient variables are statistically significant: historical growth levels in population and the spatial location of the county as measured by its longitudinal coordinates (Model C, Table 7). Like the BMA-derived base model, higher levels of historical population growth have a positive impact on employment growth, and this effect appears to be even stronger in rural Appalachia. More westerly located rural Appalachia counties appear to be experiencing faster employment growth, everything else held constant.

The amenity-augmented employment growth equation (Model D, Table 7) performs on par with Model C. Here, four of the Appalachia slope coefficients are not significantly different from zero, suggesting that for these amenities rural Appalachia is not significantly different from the rest of rural America. The land characteristic slope coefficient, however, is statistically significant. Unlike the rest of the country, where land characteristics do not appear to influence employment growth patterns, land characteristics do affect employment growth in rural Appalachia. Specifically, areas that can be described as more mountainous with recreational opportunities tend to experience more employment growth. Like the population growth equation, winter characteristics as measured by snowfall tend to dampen employment growth, although the statistical confidence of the result is weak.

The results of the BMA-derived base *per capita income* equation with Appalachia slope coefficients are provided in Table 8 (Model C). Using a strict 95 percent level of confidence, none of the Appalachia slope coefficients are statistically significant from zero, suggesting that with respect to growth in per capita income, rural Appalachia is no different than the rest of rural America. If we lower the statistical confidence level, rural Appalachia behaves differently with respect to three variables: historical growth patterns in population, percentage of houses with natural gas, and the death rate. For the United States overall, higher levels of historical population growth places downward pressure on per capita income growth, but for rural Appalachia, the opposite seems to apply. Again, unlike most of rural America, a higher percentage of houses with natural gas seems to be inversely related to growth in income. Finally, higher death rates place upward pressure on per capita income in rural Appalachia.[15] Because of the weak statistical strength of this latter result, little credence should be placed on this particular finding.

Introducing our amenity measures into our Appalachia slope coefficient model seems to reinforce the prior conclusion that rural Appalachia does not differ from the rest of rural America in terms of growth in per capita income (Model D, Table 8). The weak statistical differences discussed in Model C above appear to disappear and none of the five amenity measures are significant at the 95 percent level of confidence. At a lower level of significance, the land amenity index is positively related to growth in per capita income. Keeping in mind that areas that are more mountainous and have more recreational opportunities tend to have higher values of the land amenity index, this latter result suggests that many parts of rural Appalachia experienced greater growth in per capita income than the rest of the United States.

BMA Base Model Using Only Appalachia Data (Models E and F)

For the final step in our analysis of growth patterns in rural Appalachia, we re-estimate the BMA-derived base model along with the amenity-augmented base model using only data for Appalachia. The results of these estimates are reported as Models E and F respectively. Consider first the *population growth* equation (Model E, Table 6). For the U.S. equation the model explains 57.5 percent of the variation in population growth, but for rural Appalachia the model explains 76.9 percent of the variation in the dependent variable. Of the 15 variables in the Bayesian-derived base model, however, only five are statistically significant when using only the Appalachia data. Variables that have a positive impact on population growth include historical growth in per capita income and population, median number of vehicles per household, and the spatial location of the county along east-west longitudinal coordinates. Only one variable, the percentage of the

[15] Because death rates are included as a measure of social capital through health care, this result is on face value somewhat surprising. But a reviewer notes that this result is justifiable. Higher population growth rates in the neoclassical theory implies reduced income levels. The argument that higher death rates increase income level is an extension.

population that is non-white, has a statistically significant negative influence on population growth.

The introduction of our amenity measures (Model F) does not seem to add to the performance of the rural Appalachia-only population growth model. None of the five amenity measures are statistically significant at any reasonable level of confidence. The stability of our results on the BMA-derived base model lends credence to those results. Specifically, having higher levels of historical growth in both population and per capita income resulted in faster population growth during the 1990s. In addition, a higher number of vehicles per household along with a more westerly location are both associated with greater population growth. Finally, a higher percentage of the population that is non-white dampens population growth.

Like the population growth equation, the Appalachia-only *employment growth* equation explains a high level of the variation in the dependent variable, with an adjusted R^2 of 0.5081, which is nearly twice as high as the all-rural U.S. model (Model E, Table 7). Of the fourteen variables in the BMA-derived base model using all the data, only five are statistically significant in the Appalachia-only model. Three variables have a positive impact on employment growth, including historical growth in population, percentage of the population with a bachelor's degree, and westerly location as measured by the county's longitude coordinates. Two variables have a negative association with employment growth, including percentage of the population that is classified as non-white, as well as the percentage of the population that is foreign-born.

Like the population growth equation, the introduction of our five amenity measures does not alter the performance of the base model (Model F). With a slightly weaker level of statistical confidence, one additional variable in the base model becomes significant: federal civilian employment per ten thousand persons. Similar to Models A and B, a higher dependence on government for the employment base dampens overall employment growth. Two amenity measures appear to influence employment growth for rural Appalachia: climate and land characteristics. The climate index is inversely related to employment growth, suggesting that rural Appalachia counties that are warmer and wetter (i.e., rain and humidity) tend to have slower employment growth. The land amenity index is positively associated with employment growth, implying that the more mountainous parts of rural Appalachia are experiencing more employment growth than other parts of Appalachia.

Our final set of analyses replicates the *income growth* models using just data for rural Appalachia (Models E and F, Table 8). Like the population and employment equation, the explanatory power of the Appalachia model is stronger than that of the whole U.S. model, with an adjusted R^2 of 0.2445 versus 0.1870. For the Appalachia-only model, seven of the BMA-derived base model's fourteen variables are statistically significant at or above the 95 percent level of confidence. Those variables that have a positive impact on income growth include historical growth in population through the 1980s, income distribution where more uneven distributions of income result in positive growth, and the percentage of the population with a bachelor's degree. Four variables have a negative impact on income growth, including initial levels of income (suggesting a pattern of income convergence over time), the unemployment rate, percentage of the population with a high school degree, and percentage of the population that is foreign-born.

When we introduce the amenity measures into the Appalachia-only income growth model (Model F), only one amenity index is statistically significant: land characteristics. Consistent with Model D, the area of rural Appalachia that can be characterized as more mountainous with recreational opportunities tends to experience faster income growth, all else held constant.

Conclusions

This applied research has addressed several policy questions. First, what are the growth patterns of rural America, and does rural Appalachia differ sufficiently to warrant special policy consideration? Second, what role does amenities, both natural and built, play in rural economic growth and development? Third, can we move beyond traditional ad hoc modeling approaches and improve our theoretical and empirical insights? This research has provided noteworthy insights into each of these questions.

Using a slightly modified Carlino-Mills growth model, we provide a simple theoretical foundation for a rural amenity and growth literature that tends to be ad hoc in its approaches to modeling. Next we try to improve on the measurement of amenities by moving beyond simple scalar measure such as number of sunny days or an aggregate crime rate or a summary index that adds together a handful of scalar measures, by using principal component analysis to statistically compress several separate measures into a single index. Finally we directly tackle the problem of model specification using a Bayesian Modeling Average approach to estimate our Carlino-Mills growth equations.

Our results are encouraging. First, the expanded Carlino-Mills model captures greater dimensions of growth than what is commonly found in the amenity-growth literature. Second, our statistical approach to modeling amenities lends a greater degree of objectivity to what is commonly found in the amenity-growth literature. Third, while there are some commonalities across the whole of the United States, the country is sufficiently heterogeneous that impact of amenities or other policy variables may be significantly different depending on where one is within the country. Specifically, our results suggest that while non-metropolitan Appalachia tends to follow national trends, there are sufficient differences that warrant special attention.

Perhaps the most encouraging result from this analysis is the successful application of the Bayesian Model Averaging approach to help define the specification of the growth equations themselves. The traditional empirical growth literature has been roundly criticized as being ad hoc in the selection of right-hand-side control variables. By using the Bayesian approach we can allow the data to filter for the appropriate control variables, while the researcher can focus on the specific policy variables of interest.

While we think that the analysis presented in this applied research moves the amenity-growth literature a step forward, there are several limitations that warrant discussion. First, the development of our amenity measures, while an improvement over what is commonly found in the literature, is still ad hoc in its development. In essence, we selected a handful of variables from a long list of variables in the NORSIS data set, and combined them using principal component analysis. Greater care must be taken in building these indices. Second, we assume that the county is the correct unit of analysis and explicitly assume that there is no spillover across county lines. Clearly, these are heroic assumptions and in all likelihood wrong, and our simple attempt to control for spatial spillover or spatial dependence by including latitude and longitude coordinates is not sufficient. Despite these serious limitations, the analysis reported here moves the amenity-growth literature at least one step forward.

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APPENDIX: Initial Variables for Growth Models

Appendix Table 1. Base Set of Control Variables

DEPENDENT VARIABLES

Percentage change in per capita income, 1989–99
Percentage change in employment, 1989–99
Percentage change in population, 1989–99

CONTROLS

History

Percentage change in per capita income, 1979–89
Percentage change in population, 1989–79
Percentage change in employment, 1979–89
Per capita personal income, 1989 ($2,000)
Total population, 1989
Total employment, 1989

Markets

Race:
Percentage population non-white

Age:
Percentage population under age 18
Percentage population over age 65

Income inequality:
Entropy measure of household income equality

Poverty:
Percentage families below the poverty line
Percentage related children below poverty line
Percentage persons over age 65 below poverty line

Wealth:
Number of vehicles per household, 1990
Median value of owner-occupied housing

Labor

Labor force:
Employment 1991: civilian unemployment rate
Employment 1990: % civilian labor force female (civilian)

Education:
Education 1990: % over age 25 with at least a high school education
Education 1990: % over age 25 with at least a bachelor's degree
Percentage of persons over age 3 in public school
Percentage of persons over age 3 enrolled in school
Percentage of persons over age 3 in elementary or high school
Percentage of persons over age 3 enrolled in college
Percentage of population high school dropouts, 1990

Health:
Physicians (active non-federal) per 100,000 persons, 1990
Deaths per 1,000 persons, 1988
Community hospital beds per 100K persons, 1990
Deaths 1988: infants per 1,000 live births
Social Security beneficiaries per 1,000, December 1990

Crime:
Crimes per 1,000 persons
Arsons reported per 100,000 persons, 1990
Aggravated assaults reported per 100,000 persons, 1990
Burglaries reported per 100,000 persons, 1990
Larcenies reported per 100,000 persons, 1990
Murders reported per 100,000 persons, 1990
Motor vehicle thefts reported per 100,000 persons, 1990
Property crimes reported per 100,000 persons, 1990
Rapes reported per 100,000 persons, 1990
Robberies reported per 100,000 persons, 1990
Violent crimes reported per 100,000 persons, 1990

Nationality:
Percentage of the 1990 population foreign-born

Credit

Number of banks and savings and loan institutions per 1,000 persons

Infrastructure

Percentage of occupied units with gas
Percentage of occupied units with electricity
Percentage of occupied units with telephone

Government

Property tax as a percentage of total local tax revenue, 1986–87
Percentage change in general spending
Percentage change in federal funds and grants
Local general revenues per $1,000 income, 1986–87
Local government per capita taxes, 1986–87
State and local government employment per 10,000 persons, 1990
Federal government civilian employment per 10,000 population, 1990
Federal government military employment, 1990
Local government total intergovernmental revenue, 1986–87
Local government total tax revenue, 1986–87

Economic Structure

Percentage of population living on farms
USDA-ERS county economic base classification

Agglomeration

Proximity to metro area (higher values greater distance)
Population density (1,000 persons per square mile)

Geographical Location

Appalachian county = 1, 0 otherwise
Latitude of county
Longitude of county

Politics

Presidential voting 1992: percentage voting democratic